

Homework 1 — prerequisites and simple ML programs — assigned Monday 24 January — due Wednesday 2 February

1.1 Scheme: basic concepts (15pts)

The function *iterate* takes a function, f , of one argument as its first argument, and an integer, $n \geq 0$, as its second argument. It returns f composed with itself n times:

$$\underbrace{f(f(\dots))}_{n \text{ times}}$$

The function *rotate* takes a list, ls , and a positive integer, n , as arguments. It returns a list with all elements of ls rotated to the right n times. For example, (*rotate* '(1 2 3 4) 1) should return (2 3 4 1) and (*rotate* '(1 2 3 4) 2) should return (3 4 1 2). Write *rotate* using *iterate* and *iterate* using *compose*. Finally, write *compose*.

1.2 Scheme: program understanding (15pts)

Consider the following functions:

```
(define foo
  (lambda (key ls)
    (if (null? ls)
        #f
        (let ((x (car ls)))
          (if (eq? key (car x))
              x
              (foo key (cdr ls)))))))

(define bar
  (lambda (n)
    (letrec
      ((loop
        (lambda (x acc)
          (if (= x 0)
              acc
              (loop (- x 1) (cons (- x 1) acc))))))
      (loop n ())))))

(define mystery
  (lambda (ls n)
    (cdr (foo n (map cons (bar (length ls)) ls)))))
```

Describe in your own words what *foo* and *bar* do. Give an example input and output for each. Finally, rewrite *mystery* without using *foo* or *bar*.

1.3 Simple ML programs (15pts)

Write a function `innerproduct: (real * real * real) * (real * real * real) -> real` to compute the inner product of two real vectors in \mathbf{R}^3 represented as ML tuples.

1.4 Simple ML programs (25pts)

Write a function `innerproduct: real list * real list -> real` to compute the inner product of two real vectors in \mathbf{R}^n represented as ML lists.

1.5 Concrete mathematics (30pts)

Let

$$f(p, k, i, j) = \sum_{s=0}^p (-1)^s \frac{\binom{p}{s} \binom{p-1}{j-1} \binom{k}{s+i-j}}{\binom{p+k-1}{s+i-1}}$$

where p, k, i , and j are integers such that $2 \leq p$, $1 \leq k$, $1 \leq i \leq k$, and $1 \leq j \leq p$.

- (10pts) Express the computation of f as a Scheme function `f` of four arguments.
- (10pts) Express the computation of f as an ML function `f: {p:int, k:int, i:int, j:int} -> real`.
- (10pts) Evaluate $f(p, k, i, j)$ for various values of p, k, i , and j , form a conjecture about the value of $f(p, k, i, j)$, and prove it.

How to turn in

Turn in your code by running

```
~jackmp/cs451TA/handin your-file
```

on a regular UNM CS machine. You should use whatever filename is appropriate in place of `your-file`.

Include the following statement with your submission, signed and dated:

I pledge my honor that in the preparation of this assignment I have complied with the University of New Mexico Board of Regents' Policy Manual.